Space Weather Technical Forecast

Issued on Friday, 01 September 2023 at 13:21 Local

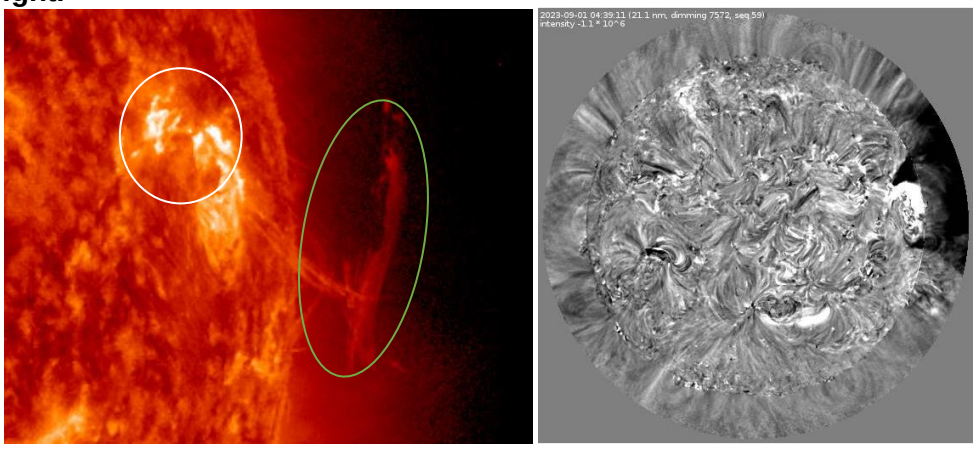
This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 (Minor-Moderate Storm) intervals poss day 2 but more likely early day 3 (02-03 Sep) due to CME arrival. Chance of Isolated M-flares (R1 Blackout)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate in the last 24 hours, with a long duration M1.2 that peaked at 01/0352UTC, originating from AR3413 in the northwest. This was preceded by a CME, clearly visible in coronagraph imagery along with an obvious coronal dimming. The CME is currently under analysis and while full details will be communicated later, it is thought to be Earth-directed.

Figure 0: SDO/AIA 304 imagery showing the M1.2 flare (white circle) and the ejecta (green ellipse) associated with the CME around 01/0300 UTC. Resulting coronal dimming on the right.



There are currently 5 sunspot regions on the visible disc, AR3413 being the largest and most complex. AR3415 remains stable, as a small bipolar region. AR3417, in the southeast, is elongated but relatively simple magnetically. The other two regions are simple unipolar spots.

A filament lift-off was also observed northwest of centre-disc at around 30/2100 UTC, along with a long period low C-class flare. An associated EUV wave was also evident in dimming imagery. This was a slightly unusual event as despite being from a source located to the northwest, the subsequent CME was to the south and slightly to the east, perhaps due to the proximity of CH40 to the northwest of the eruption. This CME has been analysed and is likely to arrive at Earth late on day 2 or early day 3 (02-03 Sep), but with low confidence.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by ACE/DSCOVR at L1, were indicative of a HSS arrival, most likely from CH40/+. The solar wind speed increased from 320 to 400km/s while density remained below average, peaking at around 450km/s. The interplanetary magnetic field, Bt, saw a slight rise, jumping from 9nT to 12nT at around

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31/1650UTC before slowly declining to 9nT. The north-south component, Bz, remained largely unchanged, fluctuating erratically between +9nT and +8nT. Phi angle became predominantly positive (away from the Sun) from 31/1640 UTC, indicating a likely connection with the HSS originating from CH40. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux rose from background levels to S1 Minor Radiation Storm shortly after 01/0400 UTC, reaching a peak of 25.8 ppcc at 01/0610 UTC. GOES16 high energy (greater than 2MeV) electron flux was at background. The associated 24-hour fluence was well below the Active threshold, with 1.22e6 integrated pfu observed at 01/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is expected to be mostly Low with a chance of rising to Moderate, most likely from AR3413 in the northwest.

Solar Wind / Geomagnetic Activity: Earth is currently under the influence of the HSS originating from CH40, with solar winds fluctuating between 400km/s and a Quiet to Unsettled geomagnetic activity. However, there is one, possibly two, Earth-directed CMEs in the forecast, which may combine to arrive late on Day 2 or early on Day 3. The results of the second CME are still pending but if confirmed, geomagnetic activity is likely to become Active with G1/G2 (Minor/Moderate) storms and a slight chance of a G3 (Strong) Storm interval on Day 3 (03 Sept).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to slowly decline towards background levels however, further Minor Storms are possible, mostly in the next two days. High energy (greater than 2 MeV) electron flux is expected to persist mainly at background, but perhaps rising briefly in response to any HSS enhancement day 2 (02 Sep), before likely dropping out again with any CME arrival. The associated 24 hour fluence is expected to remain below the Active level (1e8 integrated pfu).

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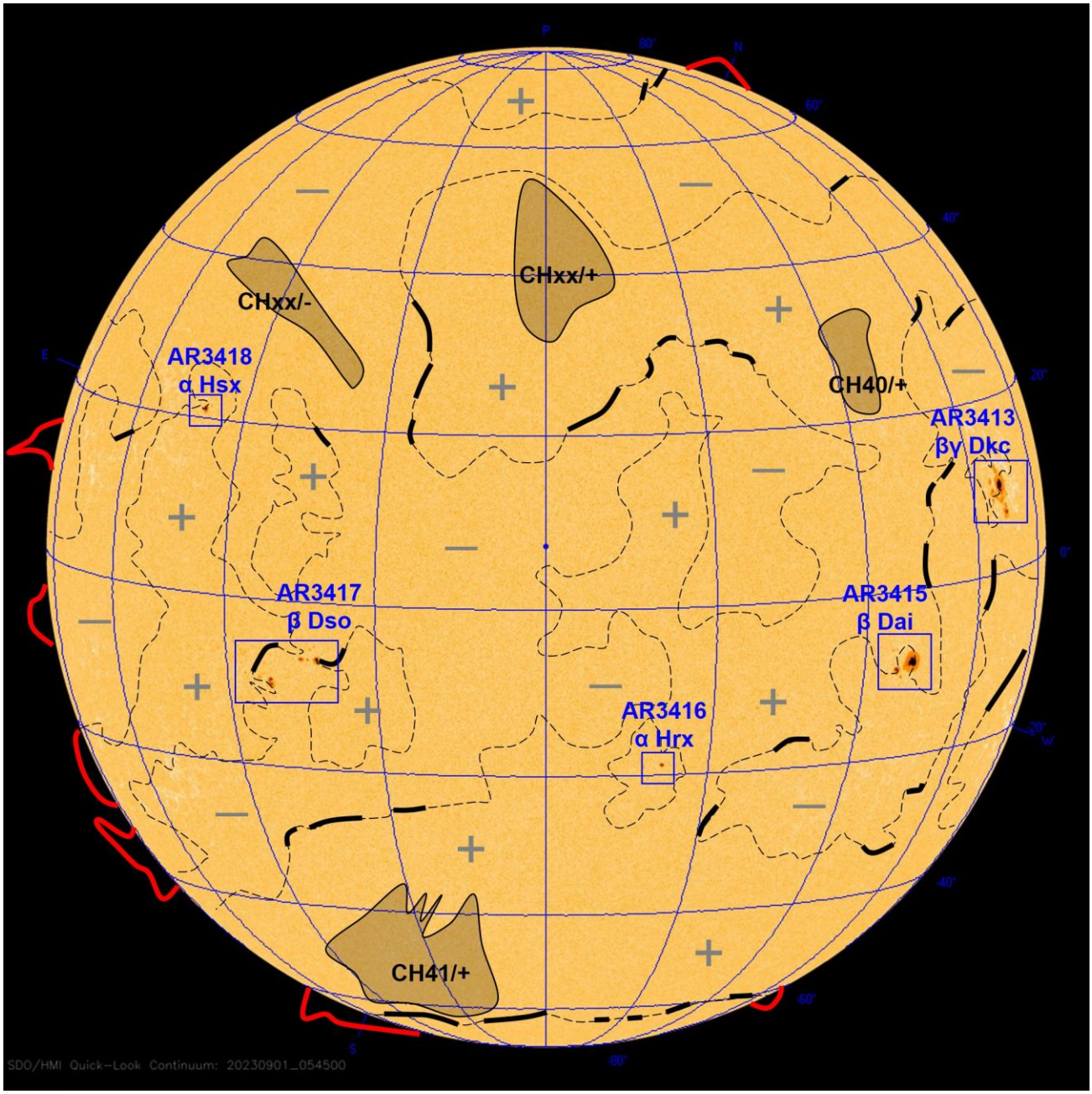
Figure 1. Solar Analysis Valid 01/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth is currently under the influence of the HSS originating from CH40, with solar winds fluctuating between 400-450km/s although they have now stabilised around 400km/s, perhaps indicating that the peak has been reached. Resulting geomagnetic activity remained quite muted, with only a few Unsettled intervals. With that in mind, solar winds are most likely to remain at their current level and will perhaps initiate a slow decline as soon as Day 2, the geomagnetic activity returning to mostly Quiet.

However, the CME from the filament eruption that occurred on 30/2100 UTC is currently anticipated to arrive late on Day 2 or early on Day 3 (02-03 Sep). The CME associated with the M1.2 flare that occurred on 01/0352UTC is under analysis. Results are still pending but it is thought to be Earth-directed and to travel with a higher velocity, thus possibly merging with the aforementioned CME on arrival. If confirmed, geomagnetic activity is likely to become Active with G1/G2 (Minor/Moderate) storms and a slight chance of a G3 (Strong) Storm interval on Day 3 (03 Sept).
Impacts are then expected to gradually wane on Day 4 (04 Sept), with Unsettled to Active intervals, although Earth may become subject to another rise of solar wind speeds in association with the HSS originating from the unnumbered coronal hole currently located over the central meridian.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	60	20
Strong	G3	No	1	5	20	2
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/0305	Partial	Filament	NW, but directed SE	610km/s	02/2200 +/- 9 hrs	Low confidence, due to unusual CME signature.

The results of the second analysis are still pending and will be communicated later.

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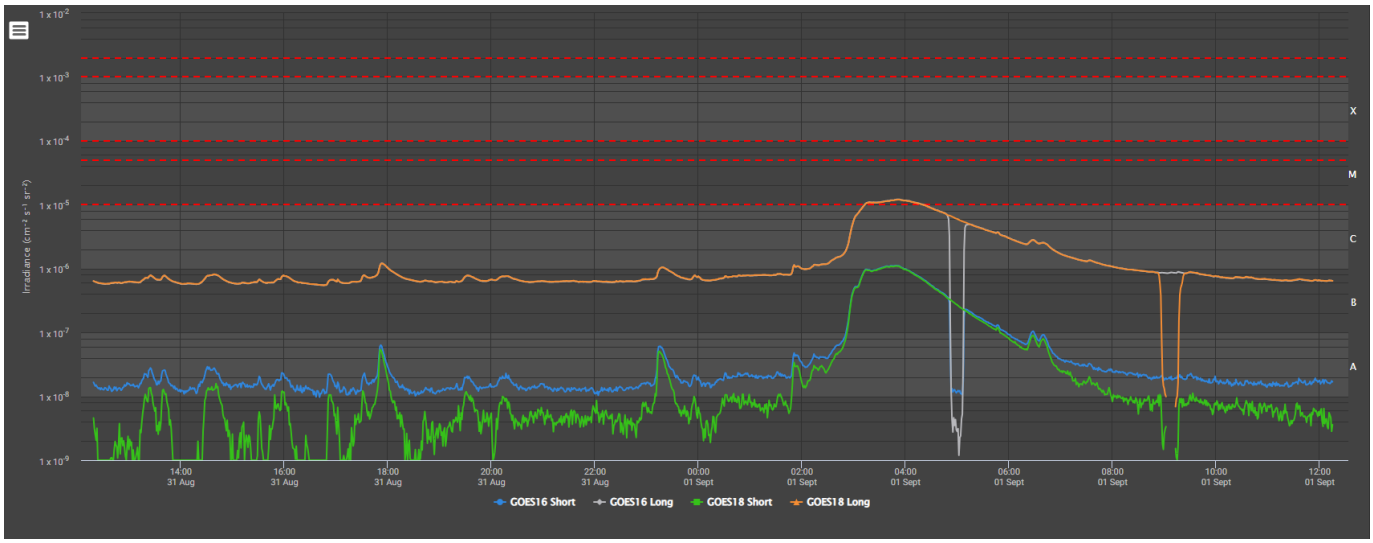
Radio Blackouts - X-Ray Flares:
Solar activity was Moderate in the last 24 hours, with a long duration M1.2 that peaked at 01/0352UTC, originating from AR3413.

There are currently five sunspot regions on the visible disc. AR3413 is the largest and most complex region, consisting of a large central sunspot around which gravitate several smaller spots. A slightly larger spot with umbra is currently developing on its southern flank. AR3415 remains stable, as a small bipolar region. AR3417 is elongated but relatively simple magnetically, with two separate entities of negative polarity followed by a rather benign region of positive polarity. AR3416 and AR3418 are both small, stable and mature unipolar spots.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	30	30	30
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 2: Latest X-Ray Flare activity, as observed by GOES-16



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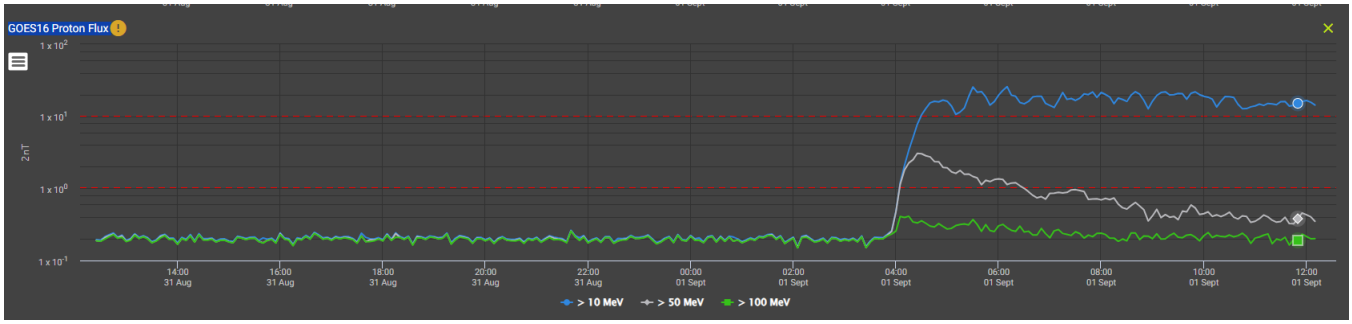
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux is currently around the S1 Minor Storm level, due to the recent long duration M1.2 flare from AR3413 in the northwest. The flux has stabilised and is expected to gradually decline towards background levels within the next 24 hours. Further enhancements are possible given the recent development of AR3413, now classified as Beta-gamma/Dkc, although the chance remains fairly low. The risk is expected to slowly decline over time as the culprit region moves further away from Earth onto the far side.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	10	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Latest Proton flux, as observed by GOES-16



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High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at background levels but likely to become enhanced during the second half of the period since a CME is anticipated late on day 2 or early day 3 (late 02 Sep or early 03 Sep). The strength of the subsequent rise in electron counts is currently unknown but it is likely to exceed High values on Day 3 and Day 4.

A further complication to the forecast is the CME that was observed after 01/0200 UTC. Should it be deemed to be Earth-directed and depending on its time of arrival, it will have a significant impact on the sequence of events and make this forecast obsolete.

All things considered the associated 24 hour fluence is likely to stay below the Active (1e8 integrated pfu) threshold throughout the period, but with an increasing risk of exceeding it late on Day 3 or into Day 4. The Met Office REFM output will not be helpful in that respect since it is based on the previous rotation and will therefore not have taken any CMEs into account.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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